

COMPASS

Recent Publications
of the Southern Research Station

Fall 2003

The Southern Research Station of the USDA Forest Service produces *Compass*, a quarterly catalog of recent publications and technologies. The Southern Station works with universities, other Government agencies, corporations, and non-government organizations on studies that contribute to the sustainability of southern forest resources. We employ about 150 research scientists in disciplines ranging from tree physiology to the social sciences, from genetics to landscape ecology. Each year, our scientists' names appear as authors on 500 to 600 journal articles, research papers, resource assessments, handbooks, videotapes, and computer programs.

In addition to featuring a few highlights, *Compass* lists our most recent publications. You can order hard copies, or download electronic versions from our Web site (**www.srs.fs.usda.gov**) by using the reference number in bold print. We welcome input on the quality of our research program and our success in offering products that meet customer needs. For more information, contact Claire Payne at 828-257-4392.

Table of Contents

Highlights

Bats in the Light of Research	1
Savannah River Site Synthesis	1
Indiana Bat Maternity Roosts	3
Tree Roots Under Radar	5
Station News	9
Coweeta Opens New Doors	9
Forest Service Names Two Emeritus Scientists	9

Research

Southern Pine Ecosystems	11
Wetlands, Bottomlands, and Streams	26
Mountain and Highland Ecosystems	32
Large-Scale Assessment and Modeling	33
Inventory and Monitoring	41
Foundation Programs	43

Research Work Units	45
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Bats in the Light of Research

Savannah River Site Synthesis

Bats stir emotions—shivers from those who fear them, awe when a female opens her wings to reveal young, fascination as they swoop to swallow mosquitoes on a humid summer night. Increasing need for conservation and interest from the general public prompted researchers at the Savannah River Site, New Ellenton, SC, to gather information about the nine species that populate this Department of Energy site managed by the Forest Service. The structure and form of bats varies drastically from birds that fly and mammals that do not, requiring a second and third look for one to get a visual fix, difficult to manage with a nocturnal animal that roosts in crevices, caves, tree cavities, and other tucked-away places. *Bats of the Savannah River Site and Vicinity*, published by the USDA Forest Service, Southern Research Station, fills the visual need with photographs of bats in native habitats sometimes as intriguing as the animals themselves.

Because the authors' earlier research at the Savannah River Site had resulted in a large dataset on bats, John Blake, Forest Service assistant manager for research on the Site, suggested a brief report about bat species and habitats. With the authors' enthusiasm to share information about these creatures that navigate by echolocation, the project grew to include assessments of how bats use major vegetation types; assessments of conservation and public health issues; identification keys; and accounts of 14 species, nine of which occur commonly on the Savannah River Site, plus five species that occur occasionally on the Site or occur in

adjacent areas. *Bats of the Savannah River Site and Vicinity* (GTR SRS-68) includes accounts of morphology and distribution; roosting ecology; foraging behavior, diet, and home range; effect of habitat type and stand age on flight activity; and reproduction. The State of South Carolina lists the southeastern myotis (*Myotis austroriparius*) and Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) as threatened and endangered, respectively. Other bats that occur regularly at the Savannah River Site include the eastern pipistrelle (*Pipistrellus subflavus*), evening bat (*Nycticeius humeralis*), silver-haired bat (*Lasionycteris noctivagans*), eastern red bat (*Lasiurus intermedius*), Seminole bat (*L. seminolus*), hoary bat (*L. cinereus*), and big brown bat (*Eptesicus fuscus*). Making land management decisions without regard for the effects they may have on bat communities no longer can be justified by claims that too little is known about habitat requirements of this diverse mammalian order. "We felt that a publication that encapsulates everything known about the foraging, roosting, and habitat selection of bats at the Savannah River Site would be a useful tool for researchers and natural resource managers," explains co-author Jennifer Menzel. *Bats of the Savannah River Site and Vicinity* provides information needed to manage bats in a complex and changing landscape.

Michael A. Menzel, a West Virginia University graduate research assistant at the time of the study, collaborated with **John C. Kilgo**, Southern Station wildlife biologist at the Savannah River Site; Jennifer M. Menzel and W. Mark Ford, wildlife biologists at the Northeastern Research Station; Timothy C. Carter, graduate research assistant at Southern Illinois

University; and John W. Edwards, assistant professor at West Virginia University.

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- 30** Menzel, Michael A.; Menzel, Jennifer M.; Kilgo, John C. [and others]. 2003. **Bats of the Savannah River Site and vicinity**. Gen. Tech. Rep. SRS-68. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 69 p.

Indiana Bat Maternity Roosts

One of the first bat species recognized as endangered by the U.S. Fish and Wildlife Service, Indiana bats hibernate in caves in the winter, some 80 percent of them in nine caves in Kentucky, Indiana, and Missouri. Even though they mate in the fall, female Indiana bats do not become pregnant until spring, when they migrate to summer tree roost sites. Forming maternity colonies of 20 to 100 members under the loose bark of roost trees, the females each bear a single young. In *Indiana Bat, Myotis sodalis, Maternity Roosts in the Southern United States*, Southern Research Station scientist **Susan Loeb** and Tennessee Technological University (TTU) researchers Michael Harvey and Eric Britzke provide the first descriptions of Indiana bat maternity habitat in the Southeastern United States.

Declines in Indiana bat populations, first noted in the 1960s, were initially attributed to human disturbance of the hibernation caves. When populations continued to decline even after caves were gated to block access, researchers began to study maternity roost locations as

a possible factor in the decline of the species. In 1999, researchers from Tennessee Technological University) found an Indiana bat roost in a dead eastern hemlock tree in the Nantahala National Forest in western North Carolina. This was the farthest south a maternity roost had ever been found, and the first report of Indiana bats using conifers for this purpose. Female bats usually move north from their winter caves, roosting in small forest tracts within the great farmlands of Missouri, Iowa, Indiana, and Illinois. The discovery of a roost so far outside the normal range started a new round of studies on the roosting behavior and range of the endangered forest bat.

Since 2000, Loeb, project leader at the Endangered, Threatened, and Sensitive Wildlife and Plants in Southern Forests unit in Clemson, SC, and her assistants, in cooperation with TTU's Harvey and Britzke, have spent long summer nights netting and tracking Indiana bats in the Great Smoky Mountains National Park in eastern Tennessee. During the summers of 2000 and 2001, they captured and radio-tagged several males and female Indiana bats and found two large maternity roosts and several smaller ones. "Although male Indiana bats have been found roosting in pine snags during the summer," said Loeb, "this study describes the first use of conifers for maternity colonies. This is very exciting because it expands the kind of habitat this endangered species can potentially use to reproduce." Like other tree-roosting bats, female Indiana bats choose several alternatives to their primary roost. The study found that the primary roosts were generally located in trees that were taller than the surrounding forest, while alternative roost trees were usually shorter than the trees around them. "Research has shown that

maternity roosts are often exposed to sunlight, and that increasing temperature inside roosts can speed the development of the young,” said Loeb. “Sun exposure may be particularly important for the roost we found in the Nantahala National Forest since it was located at a much higher elevation than any previously reported for the species.” The researchers emphasized that, although the surrounding habitat and species of the maternity roost trees differed from that usually found for Indiana bats, the structure of the roost trees was essentially the same—dead or dying trees with shedding bark. “Finding maternity roosts for outside the known range and typical habitat of this species is important,” said Loeb. “We need to continue to look for summer roosts in other areas of the Southeast previously considered outside the range of the Indiana bat.”

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- 24** Britzke, Eric R.; Harvey, Michael J.; Loeb, Susan C. 2003. **Indiana bat, *Myotis sodalis*, maternity roosts in the Southern United States.** *Southeastern Naturalist*. 2 (2): 235-242.

Tree Roots Under Radar

Southern Research Station scientists are improving the use of ground-penetrating radar (GPR) to study tree roots nondestructively. They are refining GPR’s processing capabilities by comparing results with those of more invasive methods. GPR is an electromagnetic imaging technique that can be used to detect buried objects or hidden structures. GPR has been used for geological research, archaeology, forensics, and for

assessing the integrity of roads and bridges. **John R. Butnor, Kurt H. Johnsen, and Lance Kress**, researchers at the Biological Foundations of Southern Forest Productivity and Sustainability unit, soon recognized the potential for using the technology in forest-based research. Measuring the belowground growth of trees is essential to understanding forest productivity and carbon allocation. Estimating the biomass of tree roots traditionally involves using soil cores, pits, and trenches—digging up roots, then sieving, washing, drying, and weighing them. These methods are destructive, labor-intensive, and not very useful for measuring the lateral extent of a root system.

Butnor, Johnsen, and Kress present the results of a study that assesses ground-penetrating radar (GPR) as a fast, noninvasive method to improve estimates of root biomass. The SRS scientists collaborated with J.A. Doolittle, USDA Natural Resource Conservation Service, Newton Square, PA, and L. Samuelson and T. Stokes, Auburn University, AL. “Knowing both the volume and extent of root systems is important in the carbon sequestration studies we do,” says Kurt Johnsen, director of the SRS Research Triangle Park, NC unit. “Many of the forests in the Southeast grow on land where the soil carbon has been depleted by former farming practices. In these forests, tree roots are the most dynamic pool for carbon accumulation below the ground.” For the carbon flux experiments that Johnsen and fellow researchers conduct at the Free Air Carbon Dioxide Enrichment (FACE) sites in the Duke Forest, they use a sophisticated dynamic gas sampling system to measure the effects of elevated levels of carbon dioxide on living trees. Although they can detect variability above the ground without

harming the trees, it is almost impossible to know what is going on below ground. “We need a way to measure how the root system is responding that does not involve destroying it,” Johnsen says.

John Butnor, SRS plant physiologist, has been experimenting with ways to make GPR more accurate by improving the quality of the data through advanced processing techniques, and by calibrating GPR estimates with those from soil cores. “There are a variety of factors that can affect the resolution of radar profiles of roots. Soil composition can cause background noise that interferes with resolution and alters the results,” says Butnor. “For this study, we wanted to look at the full potential of GPR, so we chose a site with soil composition amenable to radar investigations—one with electrically resistive soil of high sand content.”

In collaboration with Lisa Samuelson, Auburn University, Butnor and the other researchers used a previously established International Paper study site in Georgia, setting out sample points on plots of loblolly pine that had been fertilized or irrigated or both. For GPR sampling, they passed the radar antenna across in one direction, then the other, electronically marking sampling points on the radar profile. When they finished GPR sampling, the researchers collected soil cores at the sampling points, weighing the washed and dried roots to determine total live biomass. Butnor found that adding advanced digital processing techniques greatly improved the ability of GPR to accurately estimate root biomass. He was also able to correct for the distorting effects he found in the fertilized plots. “By closely matching the footprint of the radar antenna to the location of the soil core, we

were able to improve root biomass estimation significantly over our previous studies,” says Butnor. “The ability to correlate radar data to actual root biomass gives greater confidence in the technique and allows us to continue to make improvements.”

The researchers concluded that, in the right conditions, GPR can be used to rapidly estimate root biomass, dramatically reducing the number of soil cores that are usually needed and providing a much clearer picture of the lateral root system as it spreads out beneath the ground. “We have shown that GPR works very accurately on well-drained soils,” says Johnsen. “In a four-hour period, we can collect as much data using GPR as collected from thousands of core samples. More recently we have used GPR on flatwood sites in Florida and on heavy organic matter sites in Canada. We believe that GPR will become a standard tool in forest research, and will someday allow us to do rapid, nondestructive root assessment across many soil types.”

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- 2 Butnor, John R.; Doolittle, J.A.; Johnsen, K.H. [and others]. 2003. **Utility of ground-penetrating radar as a root biomass survey tool in forest systems.** Soil Science Society of America Journal. 67: 1607-1615.

Station News

Coweeta Opens New Doors

The Coweeta Hydrologic Laboratory hosted an open house for all members of the community Saturday, October 4, to showcase renovated and expanded research, education, and training facilities. The Coweeta Laboratory, a research unit of the Southern Research Station led by **Jim Vose**, has conducted hydrological and ecological research since 1934. Coweeta maintains a strong partnership with the University of Georgia and serves as a National Science Foundation Long-Term Ecological Research Site. Studies at Coweeta examine how land management and other disturbances influence forest resources, such as water quality, streamflow, and overall forest health. Research results have been published in more than 1,200 scientific articles and are shared with more than 1,500 visitors annually. The USDA Forest Service, the University of Georgia, and the National Science Foundation joined to cost-share funding for the project.

Forest Service Names Two Emeritus Scientists

The USDA Forest Service honored **Ron Schmidting** with the emeritus scientist award in recognition of his significant research contributions during his 35 year career. His research included pioneering work on seed orchard management to enhance tree vigor and seed production. Schmidting's systematic analysis of the southwide southern pine seed source studies led to a manual on the performance of southern pine seed

sources (GTR SRS-44). Schmidting has been an ambassador of good will and sound science within the forest tree improvement community locally, nationally, and internationally. He represents the Eastern United States on the North American Forestry Commission's working group on forest genetic resources (NAFC-FGR). Schmidting's continued involvement with the Southern Institute of Forest Genetics, Saucier, MS, will provide continuity with the NAFC-FGR and historical perspective on the Institute's existing and future work. Including military service, Schmidting retired with 40 years of federal service.

The Forest Service recognized **Glen Smalley** as emeritus scientist for his significant research contributions during his 35 year career as a soil scientist. Smalley classified and evaluated forest sites for the management of a number of commercially valuable tree species. His research provided land managers with a land classification system that enabled them to subdivide forest land into logical segments having approximate equal productivity and to recognize any limitations and hazards that the land types imposed on forest management activities. As emeritus scientist, Smalley, who retired in 1988, will continue site classification mapping and interpretation of site characteristics, assist with soil mapping in Jackson, County, AL, and conduct field tours and other technology transfer activities. He will work with a subunit of the Southern Research Station's Ecology and Management of Southern Appalachian Hardwood Forests research unit that is conducting research in the Cumberland Plateau.

Southern Pine Ecosystems

- 1 Bingham, Matthew F.; Prestemon, Jeffrey P.; MacNair, Douglas J.; Abt, Robert C. 2003. **Market structure in U.S. southern pine roundwood.** *Journal of Forest Economics.* 9: 97-117.

Time series of commodity prices from multiple locations can behave as if responding to forces of spatial arbitrage, even while such prices may instead be responding similarly to common factors aside from spatial arbitrage. Hence, while the Law of One Price may hold as a statistical concept, its acceptance is not sufficient to conclude market integration. We tested the factors hypothesized as linked to integration of forest products markets by applying a combination of bivariate and multivariate techniques. Bivariate cointegration tests were conducted for price pairs among 21 price regions and were done for both delivered southern pine sawlogs and delivered southern pine pulpwood logs. Multivariate meta-analytic regressions of cointegration test results on hypothesized explanatory factors were run for pulpwood and sawlog markets separately. Cointegration test results offer limited support for the Law of One Price in the South for both products. Results of the meta-analytic regressions show that a proxy for the cost of product transfer between regions is statistically significant and negatively related to the probability that two local market prices are cointegrated for only sawlogs. For pulpwood, the proxy was not significant. The results of the bivariate cointegration tests and the multivariate meta-analyses were used to delineate apparently spatially segmented sub-markets for both products. The maps show

overlapping geographical segments, resulting from both spatial arbitrage and possible output dominance for certain firms in those sub-markets. The southern pine sawlog market can be divided into four or five sub-markets, distributed north to south and east to west. The southern pine pulpwood log market can be drawn into three, largely separate sub-markets: a coastal zone that stretches from Texas to Virginia, and two distinct interior zones.

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- 2 Butnor, John R.; Doolittle, J.A.; Johnsen, K.H. [and others]. 2003. **Utility of ground-penetrating radar as a root biomass survey tool in forest systems.** Soil Science Society of America Journal. 67: 1607-1615.

Traditional methods of measuring tree root biomass are labor intensive and destructive in nature. We studied the utility of ground-penetrating radar (GPR) to measure tree root biomass *in situ* within a replicated, intensive culture forestry experiment planted with loblolly pine (*Pinus taeda* L.). The study site was located in Decatur County, GA, in an area of the Troup and Lucy (loamy, kaolinitic, thermic Grossarenic Kandiudults and Arenic Kandiudults, respectively) soils. With the aid of a digital signal processing GPR, estimates of root biomass to a depth of 30 cm were correlated to harvested root samples using soil cores. Significant effects of fertilizer application on signal attenuation were observed and corrected. The correlation coefficient between actual root biomass in soil cores and GPR estimates with corrections for fertilizer application were highly significant ($r = 0.86$, $n = 60$, $p < 0.0001$). Where site conditions are favorable to radar investigation, GPR can be a

powerful cost-effective tool to measure root biomass. Verification with some destructive harvesting is required since universal calibrations for root biomass are unlikely, even across similar soil types. Use of GPR can drastically reduce the number of soil cores needed to assess tree root biomass and biomass distribution. The quality and quantity of information resulting from a detailed GPR survey, combined with soil cores on a subset of plots, can be used to rapidly estimate root biomass and provide a valuable assessment of lateral root biomass distribution and quantity.

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- 3 Butnor, John R.; Johnsen, Kurt H.; Oren, Ram; Katul, Gabriel G. 2003. **Reduction of forest floor respiration by fertilization on both carbon dioxide-enriched and reference 17 year-old loblolly pine stands.** *Global Change Biology*. 9: 849-861.

Elevated atmospheric carbon dioxide (CO_2^e) increases soil respiration rates in forest, grassland, agricultural, and wetland systems as a result of increased growth, root biomass, and enhanced biological activity of soil microorganisms. Less is known about how forest floor fluxes respond to the combined effects of elevated CO_2 and nutrient amendments; until now no experiments have been in place with large forest trees to allow even preliminary investigations. We investigated changes in forest floor respiration (S_{ff}) in a *Pinus taeda* L. plantation fumigated with CO_2 by using free-air CO_2 enrichment (FACE) technology and given nutrient amendments. The prototype FACE apparatus (FACEp; 707 m²) was constructed in 1993, 10 years after planting, on a moderate fertility site in Duke Forest, NC, USA, enriching the stand to 55 Pa (CO_2^e). A

nearby ambient CO₂ (CO₂^a) plot (117 m²) was designated at the inception of the study as a reference (Ref). Both FACEp and Ref plot were divided in half and urea fertilizer was applied to one half at an annual rate of 11.2 gNm⁻² in the spring of 1998, 1999, and 2000. Forest floor respiration was monitored continuously for 220 days—March through November 2000—by using two Automated Carbon Efflux Systems. Thirty locations (491 cm² each) were sampled in both FACEp and Ref, about half in each fertility treatment. Forest floor respiration was strongly correlated with soil temperature at 5 cm. Rates of S_{ff} were greater in CO₂^c relative to CO₂^a (an enhancement of ~\$178 gCm⁻²) during the measurement period. Application of fertilizer resulted in a statistically significant depression of respiration rates in both the CO₂^a and CO₂^c plots (a reduction of \$186 gCm⁻²). The results suggest that closed canopy forests on moderate fertility sites cycle back to the atmosphere more assimilated carbon (C) than similar forests on sites of high fertility. We recognize the limitations of this non-replicated study, but its clear results offer strong testable hypotheses for future research in this important area.

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- 4 Cain, Michael D.; Shelton, Michael G. 2003. **Fire effects on germination of seeds from *Rhus* and *Rubus*: competitors to pine during natural regeneration.** *New Forests*. 26: 51-64.

Throughout the Southeastern United States, *Rhus* and *Rubus* species are common associates of the southern pines on a wide array of upland site and stand conditions. Because of their ability to overrun

disturbed sites, these species are categorized as competitors to pine during stand regeneration. Since prescribed burning is often used for site preparation in advance of pine regeneration, this study investigated the effect of fire on the germination of seeds from three pine competitors (*Rubus argutus* Link, *Rhus copallina* L., and *Rhus glabra* L.). During dormant-season burns, sumac seeds were located 45 cm above litter, within the fermentation (F) layer of a reconstructed forest floor, and at the interface of the forest floor and mineral soil. During growing-season burns, fresh blackberry fruits were placed at heights of 0, 15, 30, and 45 cm above the surface litter of a reconstructed forest floor. In subsequent germination tests, sumac seeds from within the F layer of burned litter had significantly higher germination rates for smooth sumac (31 percent) and shining sumac (42 percent) as compared to unburned control seeds (1-5 percent). In general, germination rates for sumac seeds placed in the air or on mineral soil during burning were no better than control seeds. Seeds from blackberry fruits that were located at heights of 15, 30, and 45 cm had germination rates that were comparable to unburned control seeds (18 percent), but seeds from fruits placed on the litter during burning had <1 percent germination. Results suggest that sumac seed germination may be enhanced by the heat from prescribed burning, whereas blackberry seeds showed more germination response to multiple germination cycles, which indicated a potential for long-term storage in the soil seed bank.

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- 5 Erbilgin, Nadir; Szele, Alex; Klepzig, Kier Dean; Raffa, Kenneth Francis. 2001. **Trap type, chirality of α -pinene, and geographic region affect sampling efficiency of root and lower stem insects in pine.** *Journal of Economic Entomology*. 94 (5): 1113-1121.

Root and lower stem insects cause significant damage to conifers, vector phytopathogenic fungi, and can predispose trees to bark beetle attacks. The development of effective sampling techniques is an important component in managing these cryptic insects. We tested the effects of trap type and stereochemistry of α -pinene, in combination with ethanol, on catches of the root-colonizing weevils (Coleoptera: Curculionidae) *Hylobius* spp. (mostly *Hylobius pales* (Herbst)), and *Pachylobius picivorus* (Germar), the root-colonizing bark beetle (Coleoptera: Scolytidae) *Hylastes porculus* Erickson, and the lower stem-colonizing bark beetle *Dendroctonus valens*). We tested for inter-regional differences by conducting similar field assays in the northern (Wisconsin) and southern (Louisiana) United States. The more effective trap type varied with region. Root weevils were caught primarily in pitfall traps in Wisconsin, whereas they were caught mostly in lower stem flight traps in Louisiana. In Wisconsin, root-colonizing bark beetles were also caught primarily in pitfall traps, but lower stem-colonizing bark beetles were caught primarily in lower stem flight traps. The root-feeding weevils preferred (-) over (+)- α -pinene in both regions. Some exceptions relating to trap type or gender occurred in southern populations. The two root and lower stem colonizing bark beetles in Wisconsin showed no preference between (+) and (-)- α -pinene in combination with ethanol. No bark beetles were

caught in the South. Our results suggest that modifying trap type and enantiomeric ratios of monoterpenes for different insect groups and in different regions can improve sampling efficiency for these important pests.

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- 6 Fraedrich, S.W.; Cram, M.M.; Handoo, Z.A. 2003. **Suitability of southern pines, other selected crops, and nutsedge to a *Longidorus* sp. associated with stunting of loblolly pine seedlings.** Plant Disease. 87: 1129-1132.

An undescribed needle nematode (*Longidorus* species) has been associated with severely stunted loblolly pine seedlings at a South Georgia nursery. Containers with selected crop and weed species were infested with 100 or 200 adults and juveniles of the *Longidorus* individuals to evaluate host suitability. Nematode populations increased in containers with slash, loblolly, and longleaf pine seedlings. The *Longidorus* species significantly reduced the dry root weights of slash ($P = 0.008$) and loblolly ($P = 0.047$) but not longleaf ($P = 0.095$) pine compared with controls. Populations of *Longidorus* decreased on nutsedge and small grains, including wheat, rye, oat, sorghum, and millet; and, in most experiments, populations decreased to levels found in fallow containers. Populations decreased on tomato and cabbage but increased slightly on red oak. The periodic removal of fields from pine production to grow cover crops consisting of small grains or to maintain fallow fields may be an important practice for management of this *Longidorus* species.

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- 7 Fraedrich, Stephen W.; Dwinell, L. David. 2003. **The effects of soil fumigation on pine seedling production, weeds, foliar and soil nutrients, and soilborne microorganisms at a South Georgia (U.S.A.) forest tree nursery.** Canadian Journal of Forest Research. 33:1698-1708.

Pine seedling production and pest problems were evaluated in plots fumigated with methyl bromide and nonfumigated plots over a 6-year period at a Georgia nursery. Fumigation increased bed densities for loblolly pine (*Pinus taeda* L.) in 1996 and slash pine (*Pinus elliotii* Engelm. var. *elliottii*) in 1998; differences were not observed between treatments in other years. The root collar diameter, height, and root and shoot masses of loblolly pine seedlings were often greater in fumigated plots during the first 3 years. Morphological characteristics rarely differed between treatments for slash pine. The primary pest problem was nutsedge (*Cyperus* spp.); most other weeds were controlled with herbicides used operationally at the nursery. Plant-parasitic nematode populations did not increase over time and were not a problem. Although *Fusarium* and *Pythium* spp. were more common in soil and on roots in nonfumigated plots, evidence of disease was rare. Fumigation increased the abundance of and changed the composition of *Trichoderma* spp. in soil and on roots. Soil manganese and iron, and foliar manganese, phosphorus, and nitrogen were greater in the fumigation treatment in some years. A better understanding of the risks of soilborne diseases may facilitate the development of pest management programs that are more cost-effective.

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- 8 Goyer, Richard A.; Klepzig, Kier D. 2002. **Where have all the beetles gone?** *Forests & People*. 1: 10-12.

Louisiana forests have escaped the ravages of the Southern pine beetle (SPB) since 1998. Although pine engravers (*Ips* spp.) have caused locally significant losses, these have been widely scattered. An outbreak of SPB causes its natural enemies—woodpeckers, other beetles, tiny wasps, and flies—to proliferate, driving down the SPB population. A cyclical pattern emerges, and another outbreak of SPB eventually occurs. The bluestain fungus carried by SPB plays a role in closing an outbreak also; the fungus competes with developing SPB larvae for host tissue nutrition. Changes in forestry practices create a more heavily thinned forest. Early removal of trees infested with engraver beetles; harvest of mature trees; and increased demand for all diameter sizes of timber play a role in the less active pattern of SPB outbreak in Louisiana.

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- 9 Kopper, B.J.; K.D.; Raffa, K.F. 2003. **Effectiveness of White's solution at removing ascomycetes associated with the bark beetle *Ips pini*.** *Forest Pathology*. 33: 237-240.

Modified White's solution (1 g HgCl₂/H₂O) is widely used to surface disinfect bark beetles of their phoretic fungi. We investigated the effectiveness of this solution at disinfecting adult *Ips pini* from its associated ophiostomatoid fungi. A treatment for 1, 4, or 8 minutes does not completely rid beetles of phoretic fungi, but does substantially reduce the amount of fungi they carry externally. Sterilizing with modified

White's solution caused limited mortality (< 16 percent).

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- 10** Klepzig, K.D.; Moser, J.C.; Lombardero, M.J. [and others]. 2001. **Mutualism and antagonism: ecological interactions among bark beetles, mites, and fungi.** In: Jeger, M.J.; Spence, N.J., eds. Biotic interactions in plant-pathogen associations. Wallingford, Oxon, Oxford, UK: CAB International: 237-267.

Insect-fungal complexes provide challenging and fascinating systems for the study of biotic interactions between plants, plant pathogens, insect vectors, and other associated organisms. The types of interactions among these organisms (mutualism, antagonism, parasitism, phoresy, etc.) are as variable as the range of organisms involved (plants, fungi, insects, mites, etc.) We focus on the bark beetles and their associated organisms, in particular, on the relationship between the southern pine beetle and its associates in coniferous trees of the Southern United States. We begin, however, with an attempt to clearly define the terms we use to describe these relationships.

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- 11** Lombardero, Maria J.; Ayres, Matthew P.; Hofstetter, Richard W. [and others]. 2003. **Strong indirect interactions of *Tarsonemus* mites (Acarina: Tarsonemidae) and *Dendroctonus frontalis* (Coleoptera: Scolytidae).** OIKOS. 102: 243-252. [Editor's note: Southern Research Station scientists John C. Moser and Kier D. Klepzig co-authored this paper. The citation misspells Klepzig's name as Lepzig.]

Phoretic mites of bark beetles are classic examples of commensal ectosymbionts. However, many such mites appear to have mutualisms with fungi that could themselves interact with beetles. We tested for indirect effects of phoretic mites on *Dendroctonus frontalis*, which attacks and kills pine trees in North America. *Tarsonemus* mites are known to carry ascospores of *Ophiostoma minus*, which tends to outcompete the mutualistic fungi carried by *D. frontalis*. Experimental additions and removals of mites from beetles demonstrated that *Tarsonemus* propagate *O. minus* in beetle oviposition galleries. Furthermore, the abundance of *Tarsonemus* and *O. minus* tended to covary in nature. These results verified a strong mutualism between *Tarsonemus* and *O. minus*. Results also indicated that *O. minus* is an antagonist of *D. frontalis*: beetle larvae seldom survived in the presence of *O. minus* (compared to 83 percent survival elsewhere). Apparently, this is an indirect result of *O. minus* outcompeting the two species of mycangial fungi that are critical to beetle nutrition. Thus, *Tarsonemus* mites close a loop of species interactions that includes a commensalism (mites and beetles), a mutualism (mites and *O. minus*), asymmetric competition (*O. minus* and mycangial fungi), and another mutualism (mycangial fungi and beetles). This interaction system produces negative feedback that could contribute to the endogenous population dynamics of *D. frontalis*. Reproductive rate of *Tarsonemus* was more temperature-sensitive than beetle generation time (which constrains the time for mite reproduction within a tree). This differential temperature sensitivity produces a narrow range of temperatures (centered at 27 °C) in which mite reproduction per *D. frontalis* generation can attain its maximum of 100 mites/ beetle. Consequently, seasonal oscillations in

temperature are predicted to produce oscillations in the *D. frontalis* community, and climatic differences between regions could influence the community to dampen or exacerbate the cyclical outbreak dynamics of *D. frontalis*.

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- 12** Lombardero, Maria J.; Klepzig, Kier D.; Moser, John C.; Ayres, Matthew P. 2000. **Biology, demography, and community interactions of *Tarsonemus* (Acarina: Tarsonemidae) mites phoretic on *Dendroctonus frontalis* (Coleoptera: Scolytidae).** *Agricultural and Forest Entomology*. 2: 193-202.

1. *Dendroctonus frontalis*, the southern pine beetle, is associated with a diverse community of fungi and mites that are phoretic on the adult beetles. *Tarsonemus ips*, *T. krantzii*, and *T. fusurii* (Acarina: Tarsonemidae) may interact within this community in ways that link the population dynamics of *D. frontalis*, the mites, and three dominant species of fungi. We explored species associations by comparing the dietary suitability of different fungi for *Tarsonemus* spp.

2. All three mite species fed and reproduced at high rates when feeding on the blue-stain fungus, *Ophiostoma minus*, which is an antagonist of *D. frontalis* larvae.

3. Mites also had positive population growth rates when feeding upon *Ceratocystiopsis ranaculosus*, one of the mycangial fungi, but could barely reproduce when feeding upon *Entomocorticium* sp. A, the mycangial fungus that is most suitable for *D. frontalis*.

4. During the time from colonization of a tree by *D. frontalis* adults until departure from the tree of their progeny (≈ 40 days at 30 °C), mite populations feeding

upon *O. minus* can increase by factors of up to 209 (*T. fusarii*), 173 (*T. ips*), or 384 (*T. krantzii*). These high growth rates are allowed by rapid development (age of first reproduction = 8-9 days), high fecundity (≈ 1 egg/day), and high longevity (>28 days).

5. Precocious mating increases the chance that females are mated prior to colonizing a new tree, and arrhenotokous parthenogenesis permits reproduction by unmated females.

6. Tarsonemus mites may introduce negative feedback into *D. frontalis* population dynamics by generating indirect interactions between *D. frontalis* and *O. minus*.

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- 13** Miller, D.R.; Raffa, K.F.; Dalusky, M.J.; Berisford, C.W. 2003. **North-south variation in the response of the pine engraver (Coleoptera: Scolytidae) to lanierone and ipsdienol in Eastern North America.** Journal of Entomological Science. 38 (3): 468-476.

Lindgren multiple-funnel traps were used to evaluate the response of the pine engraver, *Ips pini* (Say), to the pheromones lanierone and ipsdienol, in Wisconsin and in Southern Appalachia (western North Carolina and northern Georgia). As in Wisconsin, the attraction of *I. pini* to ipsdienol-baited traps in Southern Appalachia was strongly synergised by lanierone. In Wisconsin, *I. pini* demonstrated a strong dose-response to both lanierone and ipsdienol, preferring traps releasing lanierone and ipsdienol at the highest rates. *I. pini* in northern Georgia exhibited dose response to ipsdienol, preferring traps with lures releasing ipsdienol at the highest rate, but little in the way of a dose response to lanierone across the range of release rates tested. In Georgia, the sympatric species *I. avulsus* preferred traps

with lures releasing ipsdienol and lanierone at the highest rates.

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- 14** Miller, Daniel R. 2002. **Short-range horizontal disruption by verbenone in attraction of mountain pine beetle (Coleoptera: Scolytidae) to pheromone-baited funnel traps in stands of lodgepole pine.** Journal of Entomological Society of British Columbia. 99: 103-105.

Verbenone interrupted the attraction of mountain pine beetle, *Dendroctonus ponderosae* Hopkins, to baited multiple-funnel traps at a distance of < 4 m. Catches of beetles in traps placed \geq 4 m from traps with verbenone were not significantly lower than catches in control traps. These results are consistent with the short-range phenomenon of “switching” exhibited by mountain pine beetle in the formation of a spot infestation in stands of lodgepole pine.

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- 15** Miller, Daniel R.; Crowe, Christopher M.; Asaro, Christopher; DeBarr, Gary L. 2003. **Dose and enantiospecific responses of white pine cone beetles, *Conophthorus coniperda*, to α -pinene in an eastern white pine seed orchard.** Journal of Chemical Ecology. 29 (2): 437-451.

The white pine cone beetle, *Conophthorus coniperda*, exhibited dose and enantiospecific responses to α -pinene in stands of mature eastern white pine, *Pinus strobus*, in a seed orchard near Murphy, NC, USA. (-)- α -Pinene significantly increased catches of cone beetles

to traps baited with (\pm)-*trans*-pityol. (+)- α -Pinene did not increase catches of beetles to pityol-baited traps and interrupted the response of beetles to traps baited with (\pm)-*trans*-pityol and (-)- α -pinene. Maximal attraction of cone beetles to pityol-baited traps was obtained with lures releasing (-)- α -pinene at a rate of 103 mg/day at 23 °C. Lures releasing (-)- α -pinene at rates lower or higher than 103 mg/day resulted in reduced catches to traps baited with (\pm)-*trans*-pityol. The sex ratio in all catches was heavily male biased. Attraction of the clerid predator, *Thanasimus dubius*, to traps baited with (\pm)-*trans*-pityol increased significantly with the presence of α -pinene, irrespective of enantiomeric composition. Maximal attraction of *T. dubius* to pityol-baited traps occurred with devices releasing (-)- α -pinene at the highest rate tested, 579 mg/day at 23 °C a sub optimal rate for cone beetles.

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- 16** Veysey, Jessica S.; Ayres, Matthew P.; Lombardero, Maria. [and others]. 2003. **Relative suitability of Virginia pine and loblolly pine as host species for *Dendroctonus frontalis* (Coleoptera: Scolytidae).** *Environmental Entomology*. 32 (3): 668-679. [Editor's note: Southern Research Station scientist Kier D. Klepzig co-authored this paper.]

Dendroctonus frontalis is a major disturbance agent in American pine forests, but attack preferences for various host species, and their relative suitability for reproduction, are poorly known. We studied patterns of beetle attack and reproduction during an infestation of stands containing Virginia pine and loblolly pine. Nearly all Virginia pine were attacked and killed,

whereas a third of the loblolly pine escaped attack. Among attacked trees, the density of landings and attacks on Virginia pine was 56-106 percent higher than on loblolly pine at one site, whereas it was similar between species at another site. Paradoxically, *D. frontalis* preferred the host that was least suitable for reproduction: mean \pm SE = 0.89 ± 0.33 versus 4.65 ± 1.40 progeny attack in Virginia pine versus loblolly pine. Poor reproduction in Virginia pine was attributable to increased adult mortality, decreased oviposition, and decreased larval survival. Phloem thickness and nitrogen content were similar between the two pine species. Loblolly pine was significantly more suitable for the growth of *Ophiostoma minus*, a fungal associate of *D. frontalis*. Resin flow was lower in Virginia pine than in loblolly pine, although oleoresin chemistry may partly explain poor reproduction in Virginia pine. A simulation model predicted that beetle infestations will tend to collapse within stands dominated by Virginia pine, and that increasing availability of loblolly pines will promote infestation growth. Because of beetle preferences, forests that contain even modest proportions of Virginia pine relative to loblolly pine may be less likely to sustain beetle infestations. Management of species composition may provide a means for mitigating the undesirable impacts of this herbivore in pine forests.

Wetlands, Bottomlands, and Streams

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- 17** Bragg, Don C.; Shelton, Michael G.; Zeide, Boris. 2003.
Impacts and management implications of ice storms

on forests in the Southern United States. Forest Ecology and Management. 186: 99-123.

This review explores the ecological and silvicultural impacts of ice storms on forests in the Southern United States. Different environmental factors like weather conditions, topography, vegetation, stand density, and management practices influence the degree of glaze damage a particular forest may experience.

Additionally, the frequent contradictions in the relationships between these factors and the resulting damage suggests a complexity that makes each ice storm unique and difficult to predict. We recommend a series of silvicultural responses to ice storms, including density management, planting species selection, post-event evaluation, salvage, stand rehabilitation, and long-term monitoring of forest health.

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- 18** Connor, Kristina F.; Sowa, Sharon. 2003. **Effects of desiccation on the physiology and biochemistry of *Quercus alba* acorns.** Tree Physiology. 23 (16): 1147-1152.

Seeds that lose viability when dried to a water content of less than 12 percent are said to be recalcitrant. We subjected acorns of *Quercus alba* L., a species with recalcitrant seeds, to desiccation to determine the effects of drying on lipids, proteins, and carbohydrates of the embryonic axis and cotyledon tissues. Samples of fresh seed and seed dried for selected intervals were analyzed for water content and germination, and for lipids, proteins, and carbohydrates by Fourier transform-infrared (FT-IR) spectroscopy.

Carbohydrates were further analyzed by gas chromatography (GC).

The FT-IR analysis revealed that membrane lipid structure initially exhibited reversible shifts between gel and liquid crystalline phases in response to drying and rehydration; however, reversibility declined as viability was lost. Changes in carbohydrate concentration were observed based on peak height comparisons; sucrose concentration in the embryonic axis increased dramatically after 5 days of drying. The most sensitive indicator of desiccation damage was the irreversible change in protein secondary structure in embryonic axes and cotyledon tissue. These changes were illustrated by shifts in amide absorbance near 1650 cm^{-1} . Gas chromatography indicated an abundance of sucrose in both the embryonic axes and the cotyledon tissue. Although sucrose concentrations in these tissues were initially similar, sucrose concentration in the embryonic axes became significantly greater than in the cotyledons as the acorns dried. We hypothesize that, in drying acorns, increased concentration of sucrose does not prevent loss of viability, but acts as a glycoprotectant against cell collapse and cell wall membrane damage as water stress increases.

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- 19** Lockhart, Brian Roy; Hodges, John D.; Gardiner, Emile S.; Ezell, Andrew W. 2003. **Photosynthate distribution patterns in cherrybark oak seedling sprouts.** *Tree Physiology*. 23: 1137-1146.

We used ^{14}C tracers to determine photosynthate distribution in cherrybark oak (*Quercus pagoda* Raf.)

seedling sprouts following release from competing mid-story vegetation. Fall acquisition of labeled photosynthates by seedlings followed expected source-sink patterns, with root and basal stem tissues serving as the primary sinks. Four months after the seedlings had been labeled with ^{14}C , they were clipped to induce sprouting. First-flush stem and leaf tissues of the resulting seedling sprouts were the primary sinks for labeled photosynthates stored in root tissues. Second-flush stem and leaf tissues, and first-flush stem and leaf tissues the following growing season, were not primary sinks for labeled photosynthates stored in root tissues despite the high radioactivity in root tissues. Root tissues appeared to deposit photosynthates in a layering process whereby the last photosynthates stored in new xylem were the first to be depleted during the initiation of a growth flush the following spring. There were more labeled photosynthates in roots of released seedling sprouts compared with non-released seedling sprouts, indicating increased vigor of released seedling sprouts in response to greater light availability. In contrast, stem and source leaf tissues of non-released seedling sprouts contained greater percentages of labeled photosynthates compared with released seedling sprouts, indicating either greater sink strength or poorly developed xylem and phloem pathways that created inefficiencies in distribution to root tissues. The ^{14}C distribution coefficients confirmed the distribution patterns and provided additional information on the important sinks in released and non-released cherrybark oak seedling sprouts.

20 Marion, Daniel A.; Weirich, Frank. 2003. **Equal-mobility bed load transport in a small, step-pool channel in**

the Ouachita Mountains. *Geomorphology*. 55: 139-154.

Equal-mobility transport (EMT) of bed load is more evident than size-selective transport during near-bankfull flow events in a small, step-pool channel in the Ouachita Mountains of central Arkansas. Bed load transport modes were studied by simulating five separate runoff events with peak discharges between 0.25 and 1.34 m³/s (1.0- to 1.6-year recurrence intervals) in a natural channel using controlled releases from a storage tank. EMT occurrence was investigated using four different bed load relationships suggested by previous research. With each of these approaches, the relationship of a given bed load characteristic (D_{\max} , distribution percentile, displacement distance, and skewness) to some independent factor (τ^*_{c} , τ and grain size) was assessed to determine which transport mode was evident. Regression models derived using combinations of these four relationships with different data sets provide seven separate tests. Five of the seven tests indicate that EMT occurred or was predominant. Several reasons may explain the apparent contradictory results, but the confounding effects of changes in the structural arrangements of bed material prior to or during the events seem particularly important.

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- 21** Saenz, Daniel; Johnson, James B.; Adams, Cory K.; Dayton, Gage H. 2003. **Accelerated hatching of southern leopard frog (*Rayna sphenoccephala*) eggs in response to the presence of a crayfish (*Procambarus nigrocinctus*) predator.** *Copeia*. (3): 646-649.

Phenotypic plasticity, such as morphological and behavioral changes in response to predators, is common in larval anurans. Less is known about inducible defenses in the embryonic stages of development. We investigated the predation risk imposed by crayfish (*Procambarus nigrocinctus*) on southern leopard frog (*Rana sphenocephala*) eggs and whether crayfish presence induces a change in the timing of hatching of *R. sphenocephala* eggs. We found that crayfish significantly reduce the hatching success of *R. sphenocephala* eggs by eating them and that eggs hatch significantly faster in the presence of crayfish than when crayfish are not present. We also found that the nonlethal presence of crayfish (caged with no access to eggs) induced accelerated hatching, indicating that injured conspecifics are not required to elicit the response. Reception of chemical cues produced or released by crayfish may play an important role in survival of *R. sphenocephala* eggs.

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- 22** Sowa, Sharon; Connor, Kristina F. 2003. **Recalcitrant behavior of cherrybark oak seed: an FT-IR study of desiccation sensitivity in *Quercus pagoda* Raf. acorns.** Seed Technology. 25 (2): 110-123.

The recalcitrant behavior of cherrybark oak (*Quercus pagoda* Raf.) acorns was examined in terms of effects of moisture content on seed storage longevity and (short-term) seed germination. Seed samples collected over two consecutive years were fully hydrated, then subjected to drying under ambient conditions of temperature and relative humidity on the lab bench and sampled regularly for moisture determination (gravimetric analysis) and germination (greenhouse

conditions). Fourier transform infrared spectroscopy (FT-IR) was used to follow changes in macromolecular structure as moisture and viability were lost. Transmission spectra were collected on dry and rehydrated samples of separate embryonic axis and cotyledon tissue. Long-term storage longevity was highly dependent on initial acorn moisture content. Germination was also highly dependent on short-term moisture content, and severely declined when seed moisture dropped below 17 percent (fresh weight basis). FT-IR analyses revealed significant differences in moisture and lipid profiles between embryonic axis and cotyledon tissue during short-term drying. A strong absorbance near 1740 cm^{-1} in cotyledon tissue indicated a high concentration of ester carbonyl groups (storage lipids). Membrane lipid structure exhibited reversible shifts between gel and liquid crystalline phases upon drying and rehydration in both axes and cotyledons (peak frequency and bandwidth near 2850 cm^{-1}); however, reversibility declined as viability was lost. Irreversible changes in protein secondary structure, illustrated by shifts in the amide absorbance near 1650 cm^{-1} , were the most sensitive indicators of viability loss.

Mountain and Highland Ecosystems

- 23** Clinton, Barton D.; Yeakley, J. Alan; Apsley, David K. 2003. **Tree growth and mortality in a Southern Appalachian deciduous forest following extended wet and dry periods.** *Castanea*. 68 (3): 189-200.

We inventoried two 1-ha plots on opposing watersheds (WS2–WS-S, WS18–WS-N) three times (1983, 1989, 1998) over a 16-year period to contrast how differing precipitation (P) regimes affect tree mortality. From 1983 to 1989, annual precipitation averaged 16.5 percent less than the 64-year mean; from 1989 to 1998, it averaged 12.2 percent above the mean. In 1989 and 1998, standing crop biomass, aboveground net primary productivity, mortality rates, and species composition were determined. In 1989, following the dry period, the highest mortality for canopy tree species was in *Carya* spp. and *Quercus velutina* in both watersheds. Following the wet period in 1998, mortality was highest in *Cornus florida* in both watersheds, presumably due to the *Anthraco*se fungus; however, net change in stem density due to ingrowth was positive for this species in the WS-S watershed (+34 percent) and negative in the WS-N watershed (-18 percent). Estimated aboveground net primary production (ANPP) for WS-S was 10 and 1,076 kg ha⁻¹yr⁻¹ for the periods 1983–89 and 1989–98, respectively. In contrast, ANPP on WS-N was 679 and 93 kg ha⁻¹yr⁻¹ for the same periods. Differences in ANPP are due to higher rates of mortality on WS-N compared with WS-S. In this study, species-specific rates of mortality varied by watershed, and were likely due to microclimate-related increased susceptibility at the species level to certain proximal causes.

Large-Scale Assessment and Modeling

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- 24** Britzke, Eric R.; Harvey, Michael J.; Loeb, Susan C. 2003. **Indiana bat, *Myotis sodalis*, maternity roosts in the**

Southern United States. Southeastern Naturalist. 2 (2): 235-242.

We characterized Indiana bat (*Myotis sodalis*) roosting habitat at three maternity colony sites in western North Carolina and eastern Tennessee. Using radio telemetry, we tracked six bats a total of 40 bat days (range 4-9 days/bat). In 1999, we located a primary roost in an eastern hemlock (*Tsuga canadensis*) snag (109 cm d.b.h.) in the Nantahala National Forest, NC. In 2000, we located a primary roost in a pine (*Pinus* sp.) snag (39 cm d.b.h.) in Great Smoky Mountains National Park (GSMNP), TN. Another primary roost was found in a pitch pine snag (*P. rigida*; 55 cm d.b.h.) in GSMNP in 2001. Largest exit counts for the three colonies were 28, 23, and 81 bats. Primary roost sites were exposed to direct sunlight during most of the day. We also located six alternate roost trees: three pine snags, two red oak (*Quercus rubra*) snags, and one live sweet birch (*Betula lenta*). All three primary roosts located in this study were not used during subsequent summers. The eastern hemlock used in 1999 was still standing as of June 2001, while the two primary roosts in GSMNP had fallen within a year of being located. These records represent one of the first descriptions of Indiana bat maternity habitat in the Southern United States.

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- 25** Butnor, John R.; Doolittle, J.A.; Johnsen, K.H. [and others]. 2003. **Utility of ground-penetrating radar as a root biomass survey tool in forest systems.** Soil Science Society of America Journal. 67: 1607-1615.

Traditional methods of measuring tree root biomass are labor intensive and destructive in nature. We studied the utility of ground-penetrating radar (GPR) to measure tree root biomass *in situ* within a replicated, intensive culture forestry experiment planted with loblolly pine (*Pinus taeda* L.). The study site was located in Decatur County, GA, in an area of the Troup and Lucy (loamy, kaolinitic, thermic Grossarenic Kandiudults and Arenic Kandiudults, respectively) soils. With the aid of a digital signal processing GPR, estimates of root biomass to a depth of 30 cm were correlated to harvested root samples using soil cores. Significant effects of fertilizer application on signal attenuation were observed and corrected. The correlation coefficient between actual root biomass in soil cores and GPR estimates with corrections for fertilizer application were highly significant ($r = 0.86$, $n = 60$, $p < 0.0001$). Where site conditions are favorable to radar investigation, GPR can be a powerful cost-effective tool to measure root biomass. Verification with some destructive harvesting is required since universal calibrations for root biomass are unlikely, even across similar soil types. Use of GPR can drastically reduce the number of soil cores needed to assess tree root biomass and biomass distribution. The quality and quantity of information resulting from a detailed GPR survey, combined with soil cores on a subset of plots, can be used to rapidly estimate root biomass and provide a valuable assessment of lateral root biomass distribution and quantity.

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- 26** Fraedrich, Stephen W.; Dwinell, L. David; Cram, Michelle M. 2003. **Broadcast applications of glyphosate control nutsedge at a South Georgia forest tree**

nursery. Southern Journal of Applied Forestry. 27 (3): 176-179.

Nutsedge is a major weed problem in some southern forest tree nurseries. Although herbicides can control most weeds in nurseries, control of nutsedge is usually dependent on fumigation. The purpose of this study was to examine the effectiveness of broadcast applications of glyphosate for control of nutsedge. Single and multiple applications of glyphosate at 2.2 kg ai/ha greatly reduced the density of nutsedge shoots and viable tubers at a south Georgia forest tree nursery. The first application in June 1999 reduced nutsedge shoots by approximately 98 percent. Subsequent applications during September and October 1999 had no additional detectable effect. Although applications in August and September 2000 greatly reduced the amount of nutsedge in previously untreated areas, their effect did not appear to be as great as glyphosate applications during the first year. Rainfall before and after glyphosate applications, and plant age at the time of application may have influenced the level of nutsedge control in year two. Nutsedge shoots and viable tubers were reduced to near zero levels in plots treated over a 2 year period. The use of broadcast applications of glyphosate may be of value in developing a more cost-effective management program for nutsedge control in southern forest tree nurseries.

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- 27** Jewett, D.K.; Jiang, C.J.; Britton, K.O. [and others]. 2003. **Characterizing specimens of kudzu and related taxa with RAPD's.** Castanea. 68 (3): 254-260.

Kudzu (*Pueraria montana* (Lour.) Merr. var. *lobata* (Willd.) Maesen and Almeida) is a perennial, semi-woody, climbing legume in the tribe Phaseoleae Benth., subtribe Glycininae Benth. It is native to China, where an abundance of natural enemies and its cultivation prevent kudzu from becoming either an important economic or environmental liability. Kudzu was introduced to the United States as an ornamental during the middle of the 19th century. During the first half of the 20th century, approximately 134,760 ha were planted throughout the Southeastern United States to feed livestock and for erosion control. During 1998, kudzu was included by legislators in the United States Congress on a growing list of invasive, exotic plants recognized under the Federal Noxious Weed Law. Presently, it costs commercial forests approximately \$119/ha annually, it compromises the integrity of valuable natural resources, and dense infestations have interfered with exercises on military bases in North Carolina, South Carolina, and Virginia.

Inability to distinguish among three kudzu varieties and their possible hybrids is an obstacle to developing an integrated management program for kudzu and its related taxa. Of particular concern is selecting potential biological control agents because insects and pathogens cannot be reconciled with identity of the plants from which they were collected. Incomplete systematic resolution has been an obstacle to developing integrated management programs for other invasive, exotic plants, including *Cardaria* spp. (Brassicaceae), *Vincetoxicum* spp. (Asclepiadaceae), and *Eurphorbia* spp. (Euphorbiaceae). Using genetic markers for more convenient identification of specimens may be possible. Randomly amplified polymorphic DNA's (RAPD's) have been used successfully to characterize

genetic composition and reveal variation among genomic DNA of many important cultivated plants, including wheat, soybean, and tea. The objective of this study is distinguishing between kudzu and its related taxa using RAPD's.

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- 28** Johnsen, Kurt; Major, John E.; Maier, Chris A. 2003. **Selfing results in inbreeding depression of growth but not of gas exchange of surviving adult black spruce trees.** *Tree Physiology*. 23: 1005-1008.

In most tree species, inbreeding greatly reduces seed production, seed viability, survival and growth. In a previous large-scale quantitative analysis of a black spruce (*Picea mariana* (Mill.) B.S.P.) diallel experiment, selfing had large deleterious effects on growth but no impact on stable carbon isotope discrimination (an indirect measure of the ratio of net photosynthesis (A) to stomatal conductance (g_{wv})). It was hypothesized that selfing has no effect on carbon (C) fixation at the leaf level but impairs subsequent utilization of C. Alternatively, A and g_{wv} may be impacted by selfing to the same extent. However, no gas exchange data were collected to test these hypotheses. We have now obtained photosynthetic gas exchange data from three selfed families and three outcrossed families (all the result of controlled pollination) from the same diallel experiment. Photosynthetic responses to intercellular CO_2 concentration ($A-C_i$ curves) were generated on four replicates per family, one block per day, over a 4-day period in July. There were no differences between selfed and outcrossed families in maximum carboxylation rate, maximum electron transport, A or g_{wv} (both estimated at 370 ppm CO_2), or the ratio A/g_{wv} .

Because selfed trees had higher mortality than outcrossed trees during the experiment, we cannot exclude the possibility that previously living selfed progeny had low *A*. Nevertheless, the data indicate that inbreeding can result in trees that have low productivity despite high *A*, supporting our hypothesis that gas exchange is similar between selfed and outcrossed progeny trees. We conclude that utilization of fixed C is modified in the surviving selfed progeny.

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- 29 Lu, Jianbiao; Sun, Ge; McNulty, Steven G.; Amatya, Devendra M. 2003. **Modeling actual evapotranspiration from forested watersheds across the Southeastern United States.** *Journal of the American Water Resources Association.* 39 (4): 887-896.

About 50 to 80 percent of precipitation in the Southeastern United States returns to the atmosphere by evapotranspiration. As evapotranspiration is a major component in the forest water balances, accurately quantifying it is critical to predicting the effects of forest management and global change on water, sediment, and nutrient yield from forested watersheds. However, direct measurement of forest evapotranspiration on a large basin or a regional scale is not possible. The objectives of this study were to develop an empirical model to estimate long-term annual actual evapotranspiration (AET) for forested watersheds and to quantify spatial AET patterns across the Southeast. A geographic information system (GIS) database including land cover, daily streamflow, and climate was developed using long-term experimental and monitoring data from 39 forested watersheds across the region. Using the stepwise selection method

implemented in a statistical modeling package, a long-term annual AET model was constructed. The final multivariate linear model includes four independent variables—annual precipitation, watershed latitude, watershed elevation, and percentage of forest coverage. The model has an adjusted R^2 of 0.794 and is sufficient to predict long-term annual AET for forested watersheds across the Southeastern United States. The model developed by this study may be used to examine the spatial variability of water availability, estimate annual water loss from mesoscale watersheds, and project potential water yield change due to forest cover change.

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- 30** Menzel, Michael A.; Menzel, Jennifer M.; Kilgo, John C. [and others]. 2003. **Bats of the Savannah River Site and vicinity**. Gen. Tech. Rep. SRS-68. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 69 p.

The U.S. Department of Energy's Savannah River Site supports a diverse bat community. Nine species occur there regularly, including the eastern pipistrelle (*Pipistrellus subflavus*), southeastern myotis (*Myotis austroriparius*), evening bat (*Nycticeius humeralis*), Rafinesque's big-eared bat (*Corynorhinus rafinesquii*), silver-haired bat (*Lasionycteris noctivagans*), eastern red bat (*Lasiurus borealis*), Seminole bat (*L. seminolus*), hoary bat (*L. cinereus*), and big brown bat (*Eptesicus fuscus*). There are extralimital capture records for two additional species: little brown bat (*M. lucifigus*) and northern yellow bat (*Lasiurus intermedius*). Acoustical sampling has documented the presence of Brazilian free-tailed bats (*Tadarida brasiliensis*), but none has

been captured. Among those species common to the Site, the southeastern myotis and Rafinesque's big-eared bat are listed in South Carolina as threatened and endangered, respectively. The presence of those two species, and a growing concern for the conservation of forest-dwelling bats, led to extensive and focused research on the Savannah River Site between 1996 and 2002. Summarizing this and other bat research, we provide species accounts that discuss morphology and distribution, roosting and foraging behaviors, home range characteristics, habitat relations, and reproductive biology. We also present information on conservation needs and rabies issues; and, finally, identification keys that may be useful wherever the bat species we describe are found.

Inventory and Monitoring

- 31** Bechtold, William A.; Heravi, Nasar E.; Kinkenon, Matthew E. 2003. **A simulation algorithm to approximate the area of mapped forest inventory plots.** Gen. Tech. Rep. SRS-67. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 8 p.

Calculating the area of polygons associated with mapped forest inventory plots can be mathematically cumbersome, especially when computing change between inventories. We developed a simulation technique that utilizes a computer-generated dot grid and geometry to estimate the area of mapped polygons within any size circle. The technique also yields a

matrix of change in mapped-plot area between two points in time.

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- 32** Shaw, Dennis J.; Meldahl, Ralph S.; Kush, John S.; Somers, Greg L. 2003. **A tree taper model based on similar triangles and use of crown ratio as a measure of form in taper equations for longleaf pine.** Gen. Tech. Rep. SRS-66. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 8 p.

We used data from 322 natural longleaf pine (*Pinus palustris* Mill.) trees to include crown ratio as a continuous variable in taper equations. The data were divided into 10 crown-ratio classes and fitted taper equations into each class to detect trends in the coefficients. For application to longleaf pine, we replaced coefficients that exhibited a trend with crown ratio with a function of crown ratio. The inclusion of crown ratio as a continuous variable improved by at least 16 percent the mean square residual for both models. The authors' model performed better on the modeling dataset based on fit statistics and on the validation dataset. It also contained fewer parameters and was easier to rearrange to solve for height to a given diameter.

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- 33** Thomas, Charles E.; Roesch, Francis A., Jr. 1990. **Basal area growth estimators for survivor component: a quality control application.** Southern Journal of Applied Forestry. 14 (1): 12-18.

Several possible estimators are available for basal area growth of survivor trees, when horizontal prism (or point) plots (HPP) are remeasured. This study's comparison of three estimators not only provides a check for the estimate of basal area growth but suggests that they can provide a quality control indicator for yield procedures. An example is derived from remeasurements in Alabama for the [former] Southern Forest Experiment Station by Forest Inventory and Analysis. Remeasurements are for 1962-72 and 1972-82. It is suggested that computation of two or perhaps all three of the estimators be routinely incorporated in analysis of remeasured HPP data. Use of the two elemental estimators can provide a quality assurance check on field procedures.

Foundation Programs

- 34** Myszewski, Jennifer H.; Bridgwater, Floyd E.; Byram, Thomas D. 2003. **Determination of the minimum number of stool bed ortets required to capture a desirable genotype from full-sibling family crosses.** Southern Journal of Applied Forestry. 27 (3): 160-163.

Two important questions for clonal forestry are: (1) how many ortets must be established to ensure that one or more of the best genotypes in a family will be available for field tests and plantation establishment; and (2) how certain can one be that at least one top genotype will be present in a sample of n ortets. In this study, we calculated the level of confidence (LOC) in having included one or more desirable, rootable genotypes in a random sample of n ortets from a full-

sibling family. We also calculated the number of unique ortets required to achieve a given LOC in having included one or more desirable, rootable genotypes in a sample. In general, when the sample size is small, either because the original number of ortets was low or because of poor rootability, the LOC is lower. When rootability is low or when only a small percentage of the possible genotypes is considered desirable, the original number of ortets required to achieve a given LOC is higher. Both LOC and sample size are highly influenced by the target number of desirable genotypes to be captured in a sample of ortets.

Research Work Units

Location & Project Leader	Unit	Name & Web Site	Phone
Asheville, NC David Loftis	4101	Ecology and Management of Southern Appalachian Hardwood Forests www.srs.fs.usda.gov/bentcreek	828-667-5261
Athens, GA John Stanturf	4104	Disturbance and the Management of Southern Pine Ecosystems www.srs.fs.usda.gov/disturbance	706-559-4315
Athens, GA Jim Hanula	4505	Insects and Diseases of Southern Forests www.srs.fs.usda.gov/4505	706-559-4285
Athens, GA Ken Cordell	4901	Assessing Trends, Values, and Rural Community Benefits from Outdoor Recreation and Wilderness in Forest Ecosystems www.srs.fs.usda.gov/trends	706-559-4264
Auburn, AL Charles McMahon	4105	Vegetation Management Research and Longleaf Pine Research for Southern Forest Ecosystems www.srs.fs.usda.gov/4105	334-826-8700
Auburn, AL Robert Rummer	4703	Biological/Engineering Systems and Technologies for Ecological Management of Forest Resources www.srs.fs.usda.gov/forestops	334-826-8700
Blacksburg, VA Andrew Dolloff	4202	Coldwater Streams and Trout Habitat in the Southern Appalachians www.trout.forprod.vt.edu	540-231-4016
Blacksburg, VA Philip Araman	4702	Integrated Life Cycle of Wood: Tree Quality, Processing, and Recycling www.srs4702.forprod.vt.edu	540-231-4016

Research Work Units

Location & Project Leader	Unit	Name & Web Site	Phone
Charleston, SC Carl Trettin	4103	Center for Forested Wetlands Research www.srs.fs.usda.gov/charleston	843-727-4271
Clemson, SC Susan Loeb	4201	Endangered, Threatened, and Sensitive Wildlife and Plant Species in Southern Forests www.srs.fs.usda.gov/4201	864-656-3284
Franklin, NC James Vose	4351	Evaluation of Watershed Ecosystem Responses to Natural, Management, and Other Human Disturbances	828-524-2128
Knoxville, TN James Perdue	4801	Forest Inventory and Analysis www.srsfia.usfs.msstate.edu	865-862-2027
Monticello, AR James Guldin	4106	Managing Upland Forest Ecosystems in the Midsouth www.srs.fs.usda.gov/4106	870-367-3464
Nacogdoches, TX Ronald Thill	4251	Integrated Management of Wildlife Habitat and Timber Resources www.srs.fs.usda.gov/wildlife	936-569-7981
New Orleans, LA James Granskog	4802	Evaluation of Legal, Tax, and Economic Influences on Forest Resource Management www.srs.fs.usda.gov/4802	504-589-6652
Pineville, LA James Barnett	4111	Ecology and Management of Even-Aged Southern Pine Forests www.srs.fs.usda.gov/4111	318-473-7215

Research Work Units

Location & Project Leader	Unit	Name & Web Site	Phone
Pineville, LA Kier Klepzig	4501	Ecology, Biology, and Management of Bark Beetles and Invasive Forest Insects of Southern Conifers www.srs.fs.usda.gov/4501	318-473-7232
Pineville, LA Les Groom	4701	Utilization of Southern Forest Resources www.srs.fs.usda.gov/4701	318-473-7268
Raleigh, NC Steven McNulty	4852	Southern Global Change Program www.sgcp.ncsu.edu	919-513-2974
Research Triangle Park, NC Kurt Johnsen	4154	Biological Foundations of Southern Forest Productivity and Sustainability www.rtp.srs.fs.usda.gov/soils/soilhome.htm	919-549-4092
Research Triangle Park, NC Greg Reams	4803	Forest Health Monitoring http://willow.ncfes.umn.edu/fhm/fhm_hp.htm	919-549-4014
Research Triangle Park, NC David Wear	4851	Economics of Forest Protection and Management www.rtp.srs.fs.usda.gov/econ	919-549-4093
Saucier, MS Dana Nelson	4153	Southern Institute of Forest Genetics	228-832-2747
Starkville, MS Terry Wagner	4502	Wood Products Insect Research www.srs.fs.usda.gov/termites	662-338-3100
Stoneville, MS Ted Leininger	4155	Center for Bottomland Hardwoods Research www.srs.fs.usda.gov/cbhr	662-686-3154



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